

Outcomes of volar locking plate fixation in unstable distal radius fractures

Volar locking plate fixation

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Abstract

Aim: Unstable distal radius fractures often necessitate surgical fixation to restore anatomy and preserve wrist function. This study aimed to evaluate the functional and radiological outcomes of volar locking plate fixation in adult patients with unstable distal radius fractures.

Materials and Methods: This retrospective single-center study was conducted at a tertiary care hospital in Türkiye over a 3.5-year period. Unstable distal radius fractures were identified based on Lafontaine's radiographic criteria. All patients were treated using a volar locking plate via the Henry approach. Postoperatively, a standardized early mobilization protocol was implemented, with splint removal and initiation of wrist exercises on postoperative day 15. Functional outcomes were assessed using the Modified Mayo Wrist Score and the Turkish version of the Quick Disabilities of the Arm, Shoulder and Hand (Quick DASH-T) questionnaire, while radiological outcomes were evaluated using the Stewart radiological scoring system.

Results: A total of 51 unstable distal radius fractures were treated with volar locking plates. At final follow-up, 56.9% of patients had excellent and 21.6% had good functional outcomes, as assessed by the Modified Mayo Wrist Score. The mean Quick DASH-T score was 19.9 ± 20.4 . Radiographic parameters, including radial height, inclination, and palmar tilt, showed marked improvement postoperatively. The Stewart score indicated excellent or good results in 98% of cases. The overall complication rate was 10%.

Discussion: Volar locking plate fixation provides reliable anatomical restoration and favorable functional outcomes in patients with unstable distal radius fractures, with a low complication rate.

Keywords

distal radius fracture, volar locking plate, internal fixation, functional outcome, radiographic assessment

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Introduction

The wrist joint is a highly complex and mobile structure that plays a central role in functional hand activities. Its anatomical vulnerability contributes to a high incidence of trauma, with distal radius fractures (DRFs) being the most commonly encountered fractures of the upper limb, comprising nearly 15% of all skeletal injuries presenting to emergency departments [1]. While many DRFs are stable and amenable to conservative treatment, unstable fractures—particularly those that are intra-articular, comminuted, or associated with dorsal angulation—often require surgical fixation to restore anatomy and prevent long-term dysfunction [2]. Over the past two decades, open reduction and internal fixation (ORIF) with volar locking plates (VLPs) has become the preferred surgical technique due to its ability to provide angular stability and facilitate early mobilization [3].

Biomechanical advantages of VLPs, such as subchondral buttressing and fixed-angle screw-plate constructs, are particularly beneficial in osteoporotic bone [4]. Moreover, the volar approach significantly reduces the risk of extensor tendon irritation, which is commonly seen with dorsal plating [5]. Several prospective and retrospective studies have demonstrated excellent functional and radiographic outcomes with VLPs, including consistent restoration of volar tilt, radial height, and radial inclination [6,7]. Functional recovery, often assessed via the DASH and Mayo wrist scores, has been shown to be superior or equivalent to external fixation, with lower complication rates [8].

However, controversy persists regarding the ideal implant design, screw configuration, and optimal approach for specific fracture types [9]. This study aims to retrospectively evaluate the clinical and radiological outcomes of patients treated with VLP for unstable distal radius fractures, focusing on anatomical restoration and functional recovery.

Material and Methods

Study Design

This retrospective study was conducted at the Orthopedics and Traumatology Department of İstanbul Training and Research Hospital. Medical records of patients who presented to the emergency department between March 2010 and September 2013 and were diagnosed with unstable distal radius fractures were reviewed. Eligibility for surgical treatment was determined based on radiographic instability [10].

Radiographic assessment and classification

All patients underwent standard anteroposterior and lateral wrist radiographs at initial presentation. When necessary, computed tomography (CT) was used to further assess fracture morphology, particularly for evaluating intra-articular extension and comminution, which are critical in preoperative planning [11]. Fractures were classified using both the Frykman and AO classification systems, independently by two orthopedic surgeons.

Fracture instability was defined according to the La Fontaine criteria, which include:

- Dorsal angulation >20°
- Comminution of the dorsal cortex
- Intra-articular extension

- Associated ulnar fracture

- Age over 60 years

These criteria have been shown to strongly predict secondary displacement in conservatively treated fractures [12,13]. Patients with at least one of these features were considered to have unstable fractures and were included in the study.

Surgical technique

All surgical procedures were performed under tourniquet control with the patient in the supine position. After appropriate anesthesia (general or regional), a volar longitudinal incision was made along the flexor carpi radialis tendon. Fracture fragments were anatomically reduced, and temporary fixation was achieved with K-wires when necessary. Definitive fixation was performed using fixed-angle volar locking plates. The accuracy of reduction and implant placement was verified fluoroscopically. The pronator quadratus muscle was repaired over the plate in all cases, as standard in volar plating techniques to minimize tendon irritation [6]. All fractures were fixed using the same model of fixed-angle titanium volar locking plate.

Postoperative Management and Follow-Up

A short-arm splint in the neutral position was applied postoperatively. Patients began finger range-of-motion exercises and forearm pronation-supination movements on postoperative day 1. Wrist mobilization was initiated following suture removal on postoperative day 15, in line with early rehabilitation protocols to improve outcomes [4]. Clinical and radiological evaluations were performed at regular intervals until fracture healing and functional recovery.

Outcome measures

Functional outcomes were assessed using the Modified Mayo Wrist Score and the Turkish version of the Quick Disabilities of the Arm, Shoulder and Hand (Quick DASH-T) score, both validated tools for upper limb function [14,15]. Radiographic outcomes were evaluated using the Stewart radiological criteria, which include assessment of radial height, inclination, and volar tilt [7].

Statistical Analysis

Statistical analyses were performed using SPSS version 16.0. Descriptive statistics were used to summarize patient characteristics. The Kruskal–Wallis test was applied to compare functional and radiological scores across three predefined age groups (28–44 years, 45–60 years, and over 60 years). A p-value <0.05 was considered statistically significant.

Ethical Approval

This study was approved by the Ethics Committee of Health Sciences University, İstanbul Training and Research Hospital (Date: 2016-12-09, No: 892). Due to the retrospective nature of the study, the requirement for informed consent was waived by the committee.

Results

A total of 50 patients (28 males [56%] and 22 females [44%]) with 51 unstable distal radius fractures were included. The mean age was 50.2 years (range, 28–79). Patients were categorized into three age groups: 28–44 years (n=20, 40%), 45–60 years (n=19, 38%), and over 60 years (n=11, 22%). The most common mechanism of injury was a simple fall (70%), followed by high-energy trauma such as falls from height

(12%), motor vehicle accidents (12%), assault (4%), and bicycle accidents (2%). At final follow-up, both clinical and radiological outcomes were evaluated. According to the Modified Mayo Wrist Score, 29 cases (56.9%) were classified as excellent, 11 (21.6%) as good, 10 (19.6%) as fair, and 1 (1.9%) as poor. The mean Quick DASH-T score was 19.9 ± 20.4 (range, 0–74) (Table 1). Radiographic evaluation revealed marked improvement following surgical intervention. Mean radial height increased from 4 mm preoperatively to 15 mm postoperatively; radial inclination improved from 7° to 22°; and palmar tilt from –9° to 3°. According to Stewart’s radiological scoring system, 38 cases (74.5%) had excellent results, 12 (23.5%) were good, and 1 (2.0%) was fair (Table 2). Joint congruency was restored in all but two cases. At final follow-up, mean wrist dorsiflexion was 70° (range 55–85°), palmar flexion 75° (60–90°), ulnar deviation

Table 1. Functional Outcomes

Category	Result
Functional Outcomes (Mayo Score)	
Excellent	29 (56.9%)
Good	11 (21.6%)
Fair	10 (19.6%)
Poor	1 (1.9%)
Quick DASH-T Score (mean ± SD)	19.9 ± 20.4
DASH-T, Disabilities of the Arm, Shoulder and Hand – Turkish version; SD, standard deviation	

Table 2. Radiological Results and Range of Motion

Category	Result
Radiographic Parameters (Pre → Post)	
Radial Height (mm)	4 → 15
Radial Inclination (°)	7° → 22°
Palmar Tilt (°)	–9° → 3°
Stewart Radiological Score	
Excellent	38 (74.5%)
Good	12 (23.5%)
Fair	1 (2.0%)
Poor	0
Range of Motion (mean, °)	
Wrist Dorsiflexion	70 (55–85)
Wrist Palmar Flexion	75 (60–90)
Ulnar Deviation	35 (25–45)
Radial Deviation	25 (15–35)
Forearm Pronation	80 (75–85)
Forearm Supination	85 (75–95)

Table 3. Return to activity and complications

Category	Result
Return to Daily Activities (days)	56 (30–150)
Complications	
Carpal Tunnel Syndrome	2
Surgical Site Pain	1
Flexor Tenosynovitis	1
Sudeck’s Atrophy / Arthritis	0

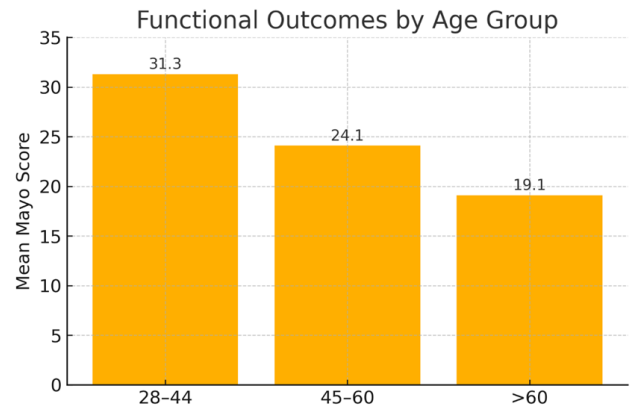


Figure 1. Functional Outcomes By Age Group

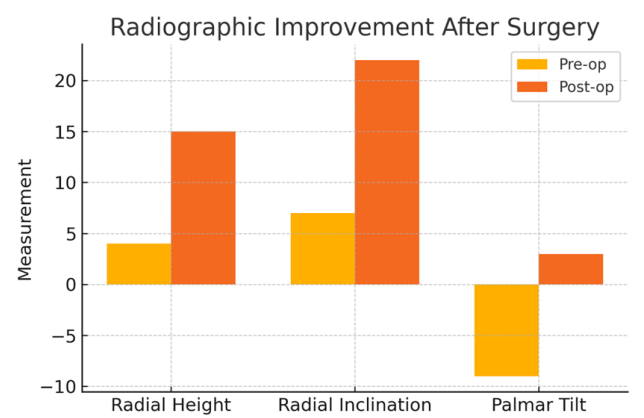


Figure 2. Radiographic Improvement After Surgery

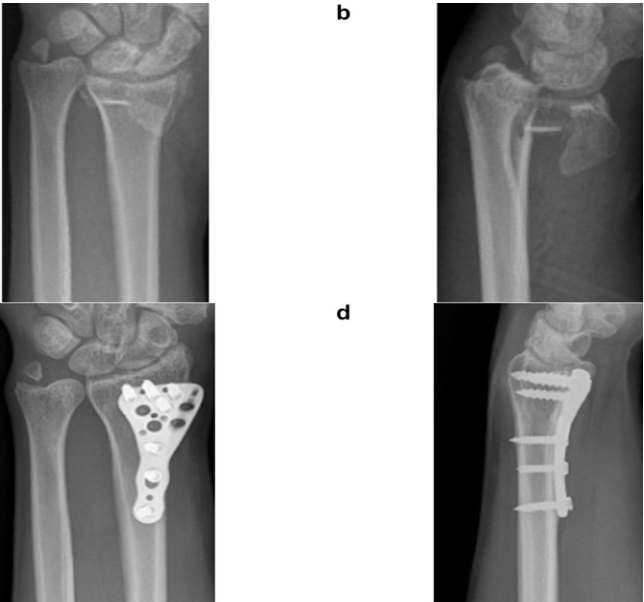


Figure 3. Preoperative (left) and postoperative (right) anteroposterior and lateral wrist radiographs of a 59-year-old female patient (Frykman type 4, AO type B2). (a) Preoperative anteroposterior radiograph showing intra-articular and dorsally angulated distal radius fracture. (b) Preoperative lateral radiograph demonstrating dorsal displacement and cortical comminution. (c) Postoperative AP radiograph after volar locking plate fixation, showing restoration of radial height and articular congruency. (d) Postoperative lateral view demonstrating correction of dorsal angulation and stable fixation with subchondral support

35° (25–45°), and radial deviation 25° (15–35°). Mean pronation and supination were 80° (75–85°) and 85° (75–95°), respectively. The average time to return to work or daily activities was 56 days (range 30–150) (Table 3). No intraoperative complications such as vascular injury or tendon rupture were observed. During follow-up, carpal tunnel syndrome occurred in 2 patients, surgical site pain in 1, and flexor tenosynovitis in 1 patient. No cases of Sudeck's atrophy or arthritis were detected (Table 3). Subgroup analysis based on age groups revealed a clear trend in functional outcomes. The mean Modified Mayo Score was highest in the 28–44 age group (31.3), followed by the 45–60 group (24.1), and lowest in patients aged over 60 years (19.1), as illustrated in Figure 1. This gradient suggests age as a potential determinant of postoperative recovery, likely reflecting both bone quality and rehabilitation potential. Radiographic parameters also demonstrated marked improvement following volar plate fixation. Radial height increased from 4 mm to 15 mm, radial inclination from 7° to 22°, and palmar tilt from –9° to 3°, supporting the anatomical restoration achieved with volar plating (Figure 2). An illustrative case example is presented in Figure 3, demonstrating the radiological improvement achieved postoperatively.

Discussion

In this study, we retrospectively evaluated 51 distal radius fractures in 50 patients who underwent volar locked plating due to instability criteria. According to the Modified Mayo Wrist Score, 56.9% of fractures had excellent outcomes, 21.6% good, 19.6% fair, and only 1.9% poor—findings that are consistent with prior reports showing favorable functional results after volar plate fixation [16]. The mean Quick DASH-T score was 19.9 ± 20.4 , in line with other studies reporting mean scores between 14 and 20 after 1 year [17]. The Stewart radiological scoring system demonstrated excellent outcomes in 74.5% of cases, similar to other prospective studies showing radiographic success rates above 70% [18]. Restoration of key radiological parameters—radial height, inclination, and palmar tilt—was achieved postoperatively [19]. Complication rates remained low, with no major tendon injuries and only one patient requiring plate removal due to pain, confirming findings of minimal complications with volar plating [20].

The management of unstable distal radius fractures remains an evolving topic. Although conservative treatment remains effective for stable extra-articular fractures, it is often insufficient in achieving long-term anatomical and functional restoration in displaced, intra-articular, or osteoporotic fractures [16]. Our patient selection was based on widely accepted instability criteria, including those by Lafontaine et al. [10], ensuring homogeneity of the cohort with true instability risk. Notably, our patients had a mean age of 50.2 years, and although over 70% of fractures resulted from simple falls, they still met criteria for instability, echoing findings by Mackenney et al. that patient age and fracture morphology are better predictors of instability than trauma mechanism alone [13]. Several radiological parameters have been associated with long-term function. Restoration of radial height and palmar tilt has been linked to improved wrist biomechanics [21]. Our postoperative values (radial height: 15 mm, inclination: 22°, tilt:

3°) and range of motion outcomes (dorsiflexion: 70°, palmar flexion: 75°, pronation-supination: near-full) align with the literature, confirming volar plating's capability to restore both anatomy and function [18,19].

The debate between dorsal and volar plating persists. Dorsal approaches carry higher risks of extensor tendon irritation and rupture, whereas volar plating, particularly when kept proximal to the watershed line, offers a biomechanically favorable and safer alternative [16,17]. In our cohort, even complex intra-articular AO type C fractures were successfully managed with volar plating alone, consistent with clinical recommendations favoring volar-only fixation for many complex patterns [16].

The overall complication rate in our study was 10%, which is favorable compared to rates up to 30% in other series [17]. Importantly, there were no extensor tendon injuries, stressing the protective benefit of the volar approach. Younger patients in our cohort achieved significantly higher functional scores, reflecting better healing potential and rehabilitation compliance, consistent with previous literature [16]. However, patients over 60 also experienced satisfactory outcomes, affirming the efficacy of stable internal fixation and early mobilization across age groups [18].

Limitations

This study has several limitations that should be acknowledged. First, its retrospective design inherently limits causal inference and is prone to selection and information bias. Second, the absence of a control group—such as patients treated conservatively or with alternative surgical techniques—precludes direct comparisons regarding the relative efficacy of volar plating. Third, the radiological evaluation was based solely on plain radiographs; advanced imaging modalities such as CT were not routinely used, potentially underestimating articular incongruities or subtle malreductions. Additionally, the functional outcomes were assessed at varying follow-up durations, which may introduce variability in the scores. Lastly, although clinical and radiological data were systematically collected, patient-reported outcome measures beyond Quick DASH-T were not utilized, limiting a more comprehensive assessment of subjective satisfaction and quality of life. Future prospective, controlled studies with standardized imaging and functional follow-up are warranted to validate and extend these findings.

Conclusion

Volar locked plating using the Henry approach was associated with reliable fracture stabilization, early mobilization, and favorable clinical and radiological outcomes in adults with unstable distal radius fractures. The low complication rate supports its continued use as a first-line surgical strategy in selected patients. Future prospective studies comparing implant designs and long-term functional recovery across age groups may further optimize treatment algorithms.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content, including study design, data collection, analysis and interpretation, writing, and some of the main line, or all of the preparation and scientific review of the contents, and approval of the final version of the article.

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with

the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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